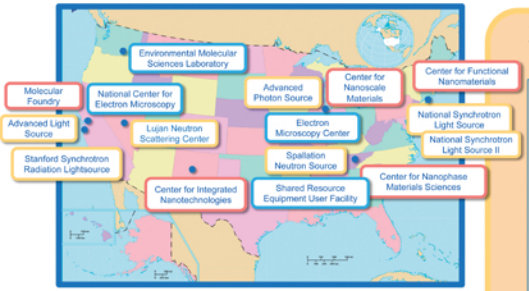
EXPLORE AND COLLABORATE
AMERICAN INDUSTRY AND AMERICA'S NATIONAL LABS
MATERIALS FOR ENERGY APPLICATIONS

USER FACILITIES FOR MATERIALS CHARACTERIZATION

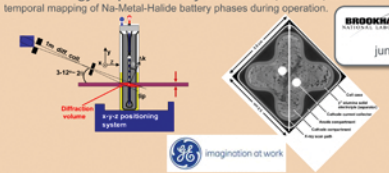
Advanced capabilities for correlating renewable energy material properties with performance



DOE User Facilities comprise a broad portfolio of world-class instruments and expertise for characterization of renewable energy materials. Facility access is granted through a peer-reviewed proposal process and facility use for research is free.

X-ray and Neutron Sources are highly sophisticated, centralized tools staffed by specialists, providing Users with the ability to characterize materials at the atomic and molecular level and understand how materials behave under different external conditions.

In-situ Energy Dispersive X-ray Diffraction provides spatial and temporal mapping of Na-Metal-Halide battery phases during operation.



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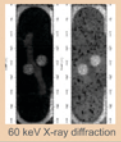
High Energy X-rays are useful for penetrating large cross-sections of a cycled battery to locate different material components.



60 keV X-ray diffraction

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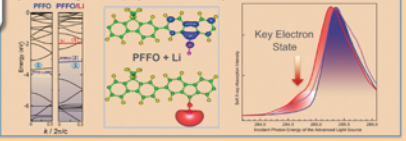
Soft X-ray Absorption Spectroscopy provides valuable feedback in synthetic design of new polymer-based battery materials.



Grazing Incidence X-ray Diffraction from polymer solar cell materials measures molecular structure under different processing conditions.

2D diffraction pattern shows ordered crystalline structure with a mixed plane-on/edge-on orientation

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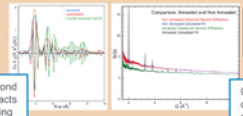
X-ray Absorption Fine Structure and **Neutron Scattering** quantify chemical changes to the solar material Cu_2ZnSnS_4 upon thermal annealing.



Cu-S bond length contracts upon annealing

Cu-Zn substitution obtained from neutron data

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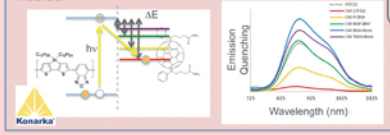
Nanoscale Science Research Centers provide state-of-the-art capabilities for fabrication, synthesis, and characterization of nanostructured materials, emphasizing nanometer-level control to achieve desirable properties. Here, **Advanced Optical Characterization** capabilities for renewable energy materials are highlighted.

Facilities include:

- Cleanroom thin-film nanofabrication
- Electron microscopy
- Proximal-probe based microscopy
- Advanced optical characterization
- Materials synthesis (organic and inorganic)
- Theory and computation

Time-Resolved Optical Absorption and Emission Spectroscopy characterizes the rate and magnitude of charge formation in polymer solar materials.



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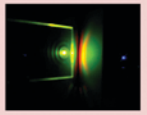
Angle-Resolved Spectroscopies are valuable for characterizing optical cavities and structures for solar energy conversion.



Optical image of a functioning resonance-shifted luminescent solar concentrator

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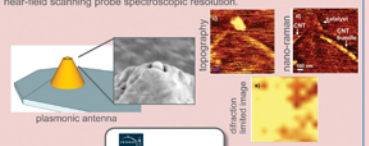
Next-Generation Plasmonic Antennas significantly improve near-field scanning probe spectroscopic resolution.



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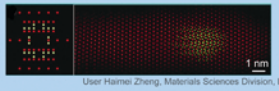
Electron Microscopy Centers maintain some of the world's most advanced electron microscopes and expertise for studying the structure of materials at atomic resolution and understanding how atoms combine to make materials.

The TEAM 0.5 instrument is one of the world's most powerful transmission electron microscopes, using aberration-correcting optics to image atoms with unprecedented spatial resolution.



User Haimei Zheng, Materials Sciences Division, LBNL

Fourier transform pattern (left) and high resolution TEM images of the low-chalcocite (green) and high-chalcocite (red) domains in a copper sulfide nanorod.

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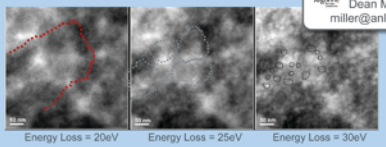
Chromatic-Aberration-Corrected Transmission Electron Microscopy reveals the nanometer-scale domain structure in blended organic semiconductors that are key to their photovoltaic performance.



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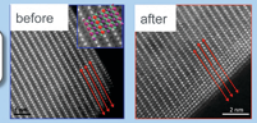
High-Resolution Scanning Transmission Electron Microscopy of layered $LiTMO_2$ in high voltage Li-ion batteries - before and after repeated charge-discharge cycling - illuminates material degradation mechanisms.



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In-Situ Transmission Electron Microscopy permits direct observation of lithiation/delithiation processes in SnO_2 nanowire materials.

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Office of Science